CHAPTER 2

INTRODUCTION TO LASERS

The word *laser* is an acronym for Light Amplification by Stimulated Emission of Radiation. The first lasers were used for surveying applications, as they gave an accurate measurement of distance. As the technology increased, laser systems were adapted for military applications. The initial application was for gunfire control. Today, lasers are used in the military for range finding, target designation, communications, target detection, and landing systems, and training aids. In the civilian community, lasers are used in the medical field and for welding, cutting, surveying, and communications.

CHARACTERISTICS OF A LASER

A simplified illustration of a typical solid-state laser is shown in figure 2-1. The elements of the laser are:

- Lasing material (crystal, gas, etc.)
- Pump source (flash lamp, electron collision, etc.)
- Optical cavity
- Laser radiation

Lasers operate on the principle of stimulated emission. Electrons in the atoms of the lasing material reside in a steady-state. When energy is added to an atom, an unstable condition occurs when its electrons are excited to a higher energy level. The electrons will stay in this state for a short time and then decay back to their original energy state. This decay occurs in two ways:

1. Spontaneous decay—the electrons simply fall to their ground state while emitting randomly directed photons; and

2. Stimulated decay—the photons from spontaneous decaying electrons strike other excited electrons, which causes them to fall to their ground state.

This transition through stimulated decay will release energy in the form of photons of light that travel in phase and in the same direction as the incident photon. If the direction is parallel to the optical axis, the emitted photons will travel back and forth in the optical cavity, through the lasing material, between the 100-percent reflecting mirror and the 99-percent reflecting mirror. The light energy is amplified each time the beam passes through the lasing material. When sufficient energy is built up in the beam, a burst of light will be transmitted through the 99-percent reflecting mirror. This action is called lasing.

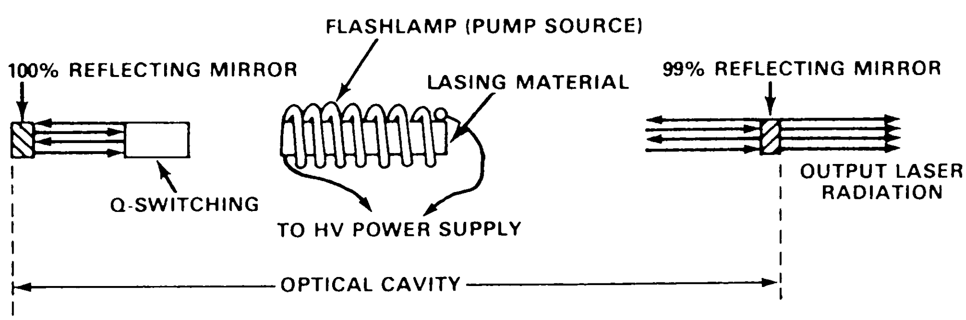


Figure 2-1.—Typical solid-state laser configuration.

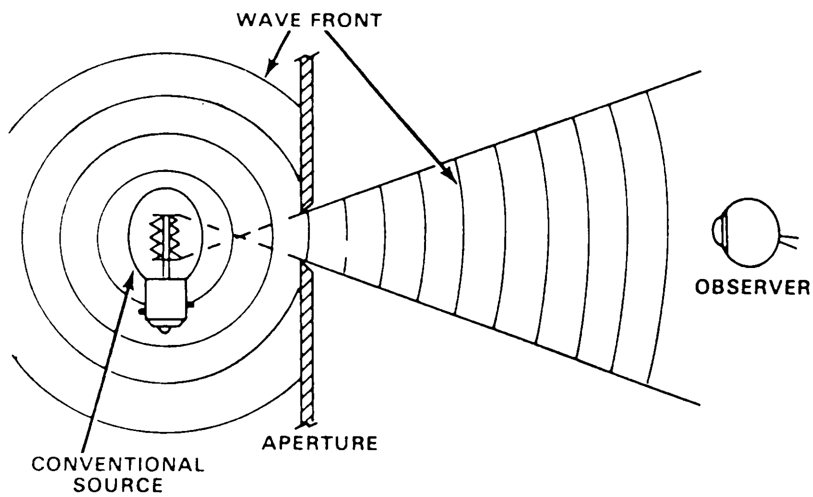


Figure 2-2.-Divergence of a conventional light source.

Light from a conventional light source spreads rapidly, as illustrated in figure 2-2. The intensity may be large at the source, but it decreases rapidly as the distance from the source increases. In contrast, the output of the laser, shown in figure 2-3, has a very small divergence and the beam intensity at reasonable distances is almost the same as the intensity at the source. Therefore, relatively low-power lasers project more energy at a single wavelength within a narrow beam than do much more powerful conventional light sources.

CHARACTERISTICS OF REFLECTIVE MATERIALS

Material will either reflect, absorb, or transmit light rays. Reflection of light is best illustrated by a mirror. When light rays strike a mirror, almost all of the energy will be reflected. Figure 2-4 shows how a ray of light is redirected as it strikes a plastic or glass surface. The sum of the energy transmitted, absorbed, and reflected will equal the amount of energy that strikes the surface.

A surface is considered to be *specular* if the size of the surface imperfections and variations are much smaller than the wavelength of the striking optical radiation. When the imperfections are randomly oriented and are much larger than the wavelength, the surface is considered to be *diffuse.*

Specular Reflection

A flat specular surface will not change the divergence of the striking beam of light significantly.

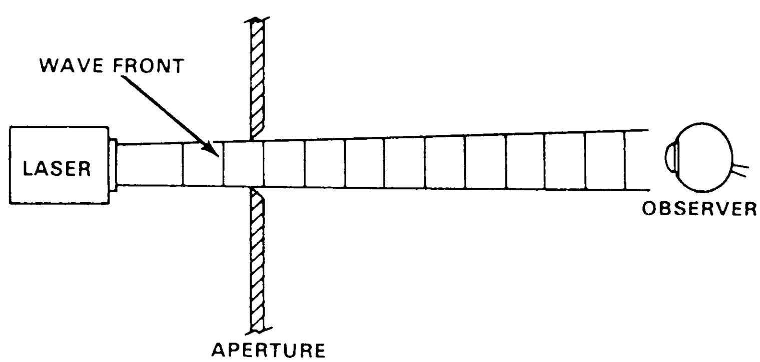


Figure 2-3.—Divergence of a laser source.

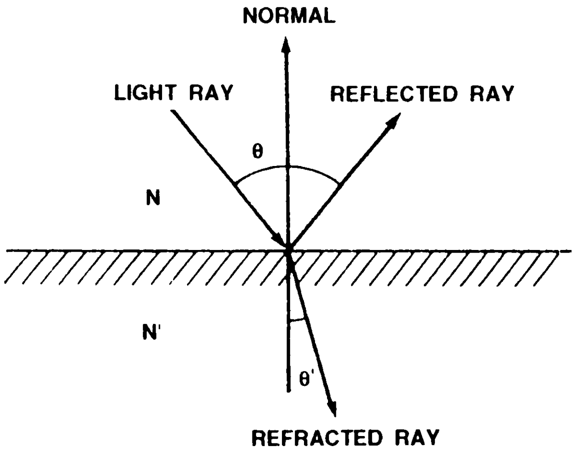


Figure 2-4.—Light ray striking a glass surface.

However, curved specular surfaces may change the divergence. The amount that the divergence is changed depends on the curvature of the surface and the size of the beam striking the surface. Figure 2-5 illustrates these two surfaces and how they will reflect a laser beam striking them. (Note: The divergence and curvature of the reflector have been exaggerated to better illustrate the effect.)

Diffuse Reflection

A diffuse surface will reflect the striking laser beam in all directions. The beam path is not maintained when a laser beam strikes a diffuse reflector.

Whether a surface acts as a diffuse or specular reflector depends on the wavelength of the striking laser beam. A surface that would be a diffuse reflector for a visible laser beam might be a specular reflector for an infrared laser beam.

As opposed to specular reflectors, various curvatures of diffuse reflectors have little effect on the reflected beam (figure 2-6).

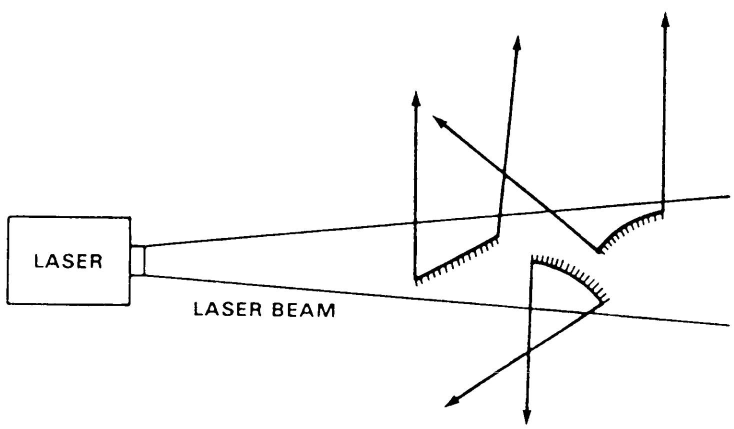


Figure 2-5.—Specular reflection.

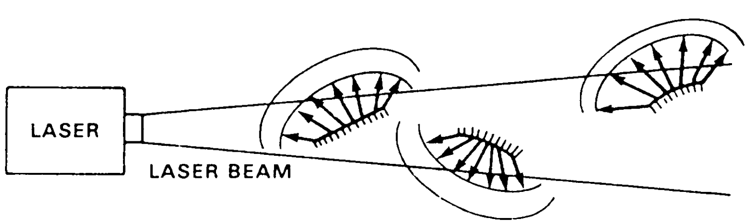


Figure 2-6.—Diffuse reflections.

LASER CLASSIFICATION

As lasers became more numerous and more widely used, the need to warn users of laser hazards became apparent. To meet this need, laser classifications were established. Current classification levels vary from optically safe, requiring no controls (Class 1) to very hazardous, requiring strict controls (Class 4).

CLASS 1

A Class 1 laser or laser system emits levels of optical energy that are eye-safe and consequently require no controls. An example of this class of laser system is the checkout scanning device found in most grocery stores.

CLASS 2 AND CLASS 3A

Class 2 and Class 3A lasers emit visible, continuous-wave (CW) optical radiation levels slightly above the maximum permissible exposure (MPE) level. Although these lasers can cause eye damage, their brightness usually causes observers to look away or blink before eye damage occurs. These lasers have strict administrative controls requiring placement of signs warning personnel not to stare directly into the beam (figure 2-7).

WARNING

Class 3A lasers must not be viewed with optically-aided devices.

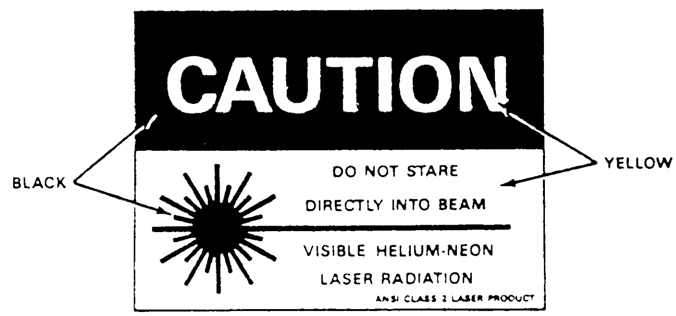
CLASS 3B

Class 3B lasers, and Class 3A lasers with outputs of 2.5mW, are hazardous to personnel who are within the beam path and look at the beam source directly or by specular reflection. These lasers cannot produce hazardous diffuse reflections.

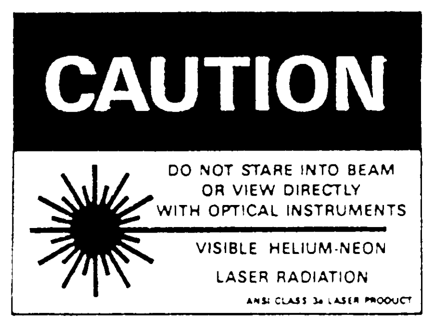
Personnel working with these lasers should wear appropriate protective eyewear during any operation of the laser. Class 3B lasers have both administrative and physical controls to protect personnel. Physical controls include limited access work areas. Administrative controls include special warning signs posted outside the entrances to the laser work spaces and lights outside the entrances that warn personnel when the lasers are in use. Figure 2-8 illustrates a laser maintenance area warning sign.

CLASS 4

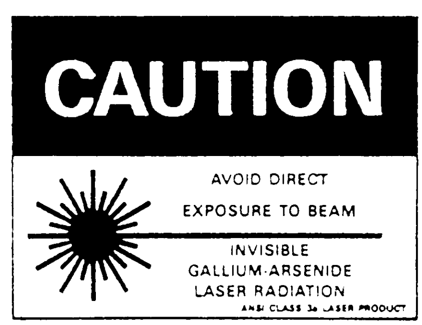
Class 4 lasers are high-power lasers that will cause damage to unprotected eyes and skin through intra-beam viewing and specular or diffuse reflections. Consequently, no personnel should be in a room where a Class 4 laser is operating without



(A)



(B)



(C)

Figure 2-7.—Examples of laser warning labels: A. Class 2; B. Class 3A visible and near infrared; C. Class 3A infrared and ultraviolet.

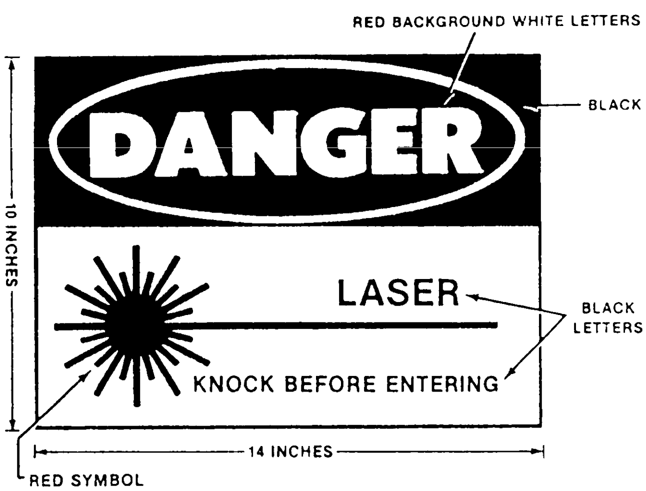


Figure 2-8.—Laser maintenance area warning sign.

appropriate laser-protective eyewear and appropriate clothing. Other controls include the use of warning lights, signs stating the danger involved, and the control measures provided for Class 3B lasers.

Figure 2-9 illustrates warning labels for Class 3B and Class 4 lasers.

LASER EQUIPMENT

In the following paragraphs we will discuss a few of the types of laser equipment found in the Navy today. There are three categories of laser equipment: markers/designators, pointers/aiming devices, and rangefinders. This equipment is used for target designation, aimed firing, and target ranging, thereby enhancing our tactical ability.

MARKERS/DESIGNATORS

Markers are used to mark objects as targets for laser-guided weapons. Designators are used to designate an object in a cluster of objects as a target for laser-guided weapons.

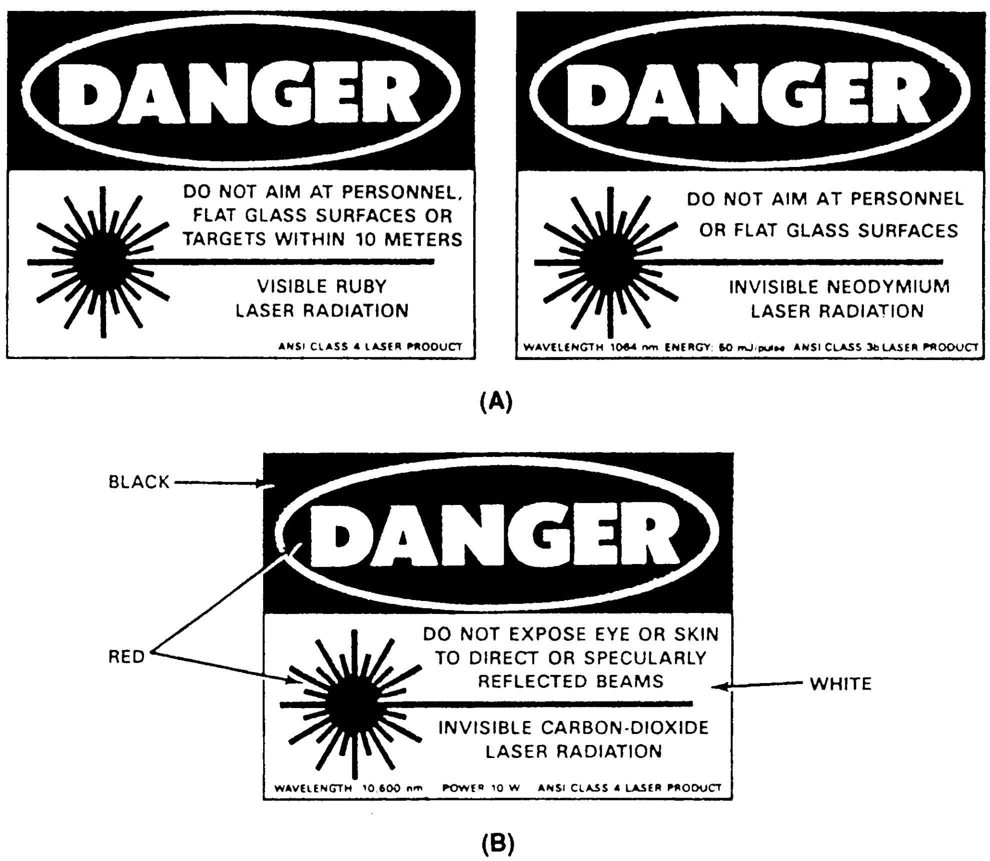


Figure 2-9.—Examples of laser warning labels: A. Class 3B and Class 4 visible and near infrared; and B. Class 3B and Class 4 infrared and ultraviolet.

LTM86 Compact Laser Designator (CLD)

The LTM86 CLD, illustrated in figure 2-10, is a man-portable unit used to obtain a close estimate of range to a target or to designate a target for laser guided munitions.

The CLD is a Class 4 laser with a 7-degree field of view and a range of 5 kilometers when used as a designator, and 50 meters to 10 kilometers when used as a rangefinder. It can be powered by either a lead acid mission battery or a nickel-cadmium training battery. Safety eyewear must have an optical density (OD) with a rating of 4.5 at a wavelength of 1064 nano-meters.

Special Operations Forces Laser Marker (SOFLAM)

The SOFLAM, illustrated in figure 2-11, is a compact, lightweight, man-portable unit that is used to obtain a close estimate of range to a target or to designate a target for laser-guided munitions. This unit has provisions for tripod mounting and remote operation and can directly accept a night vision sight for 24-hour observation.

The SOFLAM is a Class 4 laser that has a 5.6-degree field of view and a range of 5 kilometers as a designator and 200 meters to 10 kilometers as a rangefinder. It weighs 9.1 pounds and is powered by a either BA 5590 lithium battery, a BB 590 rechargeable battery, or 28-volt vehicular power. The safety eyewear must have an OD of 4 at a wavelength of 1064 nano-meters.

POINTERS/AIMING DEVICES

These devices are used for aimed firing of hand-carried weapons. They will produce a splash of light at the point of impact for the weapon's projectile.

TD-100A Laser Target Designator (Aiming Device)

The TD-100A, illustrated in figure 2-12, is a self-contained battery-powered optical sighting/laser aiming device designed for mounting on the M12A1 rifle or the MP5 9MM submachine gun. A red spot

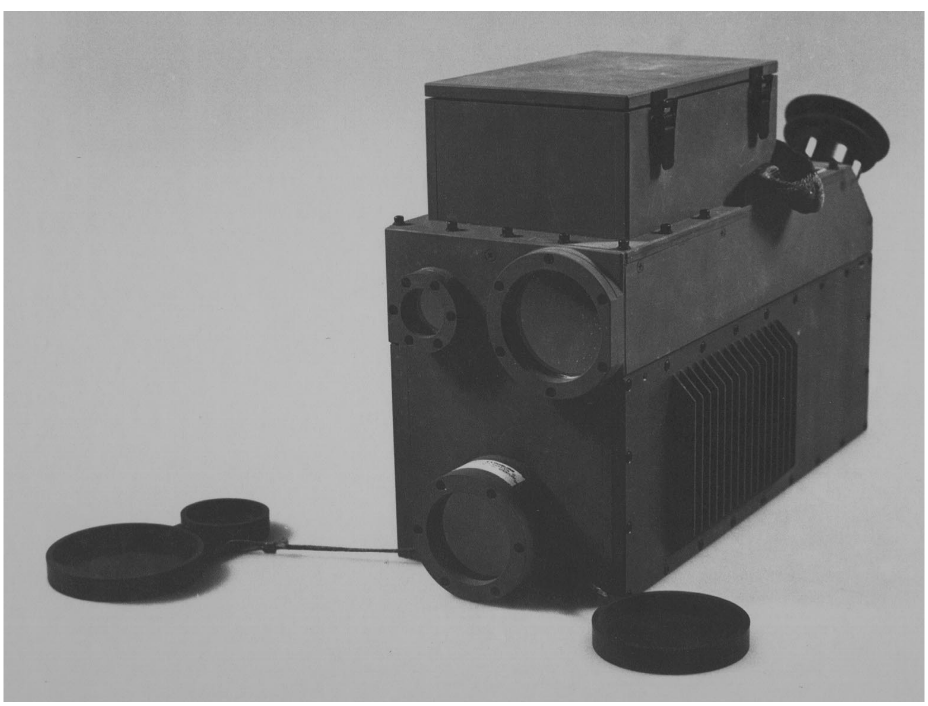


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Figure 2-10.—LTM86 CLD.

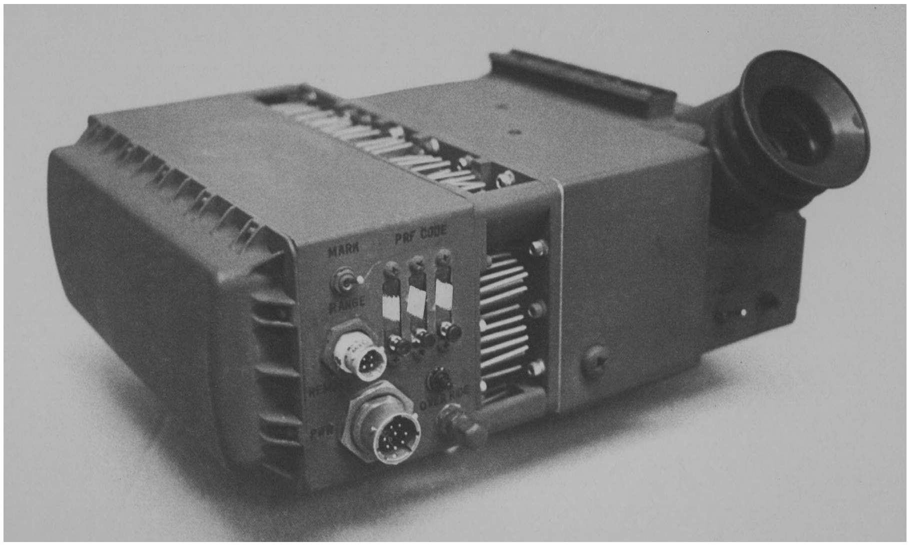

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Figure 2-11.—SOFLAM.

(visible mode) or an infrared pulsed spot (IR mode) indicates the impact point of a round fired from a TD-100A-equipped weapon.

The TD-100A is a Class 3B laser device with a range of 50 yards in the visible mode and 300 yards in the infrared mode. It is powered by a nickel-cadmium battery pack or an alkaline battery pack, and weighs 1.55 pounds. Safety eyewear must have an OD of 1 at a wavelength or 670 nano-meters for the visible mode and an OD of 1 at a wavelength or 850 nano-meters for the infrared mode.

NOTE

Night vision equipment is required for infrared use of this device.

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Figure 2-12.—TD-100A mounted on an MP5 9MM submachine gun.

AIM-1DLR Laser Aiming Device

The AIM-1DLR, illustrated in figure 2-13, is a weapon-mountable aiming device with an adjustable-intensity beam used as a long range pointer. This unit can operate with any type of night vision system.

This unit is a Class 3B laser with a range of 3000 meters and weighs only 9 ounces. It is powered by two BA 3058 "AA" alkaline batteries. Safety eyewear for this unit must have an OD of 1.67 at a wavelength of 840 nano-meters. The note preceding this section also applies to the AIM-1DLR.

RANGEFINDERS

Rangefinders are devices that are used to find a close estimate of the distance to a target quickly.

AN/PVS-X Miniature Laser Range Finder (MLRF)

The AN/PVS-X, illustrated in figure 2-14, is a small, man-portable, lightweight, hand-held unit used to obtain a close estimate of the range to a target.

The AN/PVS-X MLRF is a Class 3B laser that weighs 2.5 pounds and has a range of 50 meters to 10 kilometers, with a 7-degree field of view. It can be powered by either four BA 5567 lithium or four BA 1567 Mercury or a battery pack containing eight BA 3058 "AA" alkaline batteries. Safety eyewear for this unit must have an OD of 3.7 at a wavelength of 1064 nano-meters.

M931 Ranging Night Scope (RNS)

The M931 RNS, illustrated in figure 2-15, is a man-portable, lightweight, hand-held or tripod-mounted laser device. It is used to obtain a close estimate of range to a target under starlit or moonlit conditions. The M931 is a Class 3B laser with a 13.6-degree field of view and a range of 1 kilometer. It weighs 2.9 pounds and is powered by four "AA" 3.5-volt lithium batteries. Safety eyewear for the M931 must have an OD of 1 at a wavelength of 830 nano-meters.

THERMAL IMAGING

Thermal imaging is a process by which heat emissions (infrared energy) are converted to visible light. Thermal imaging devices detect and display changes in the heat emissions of objects.

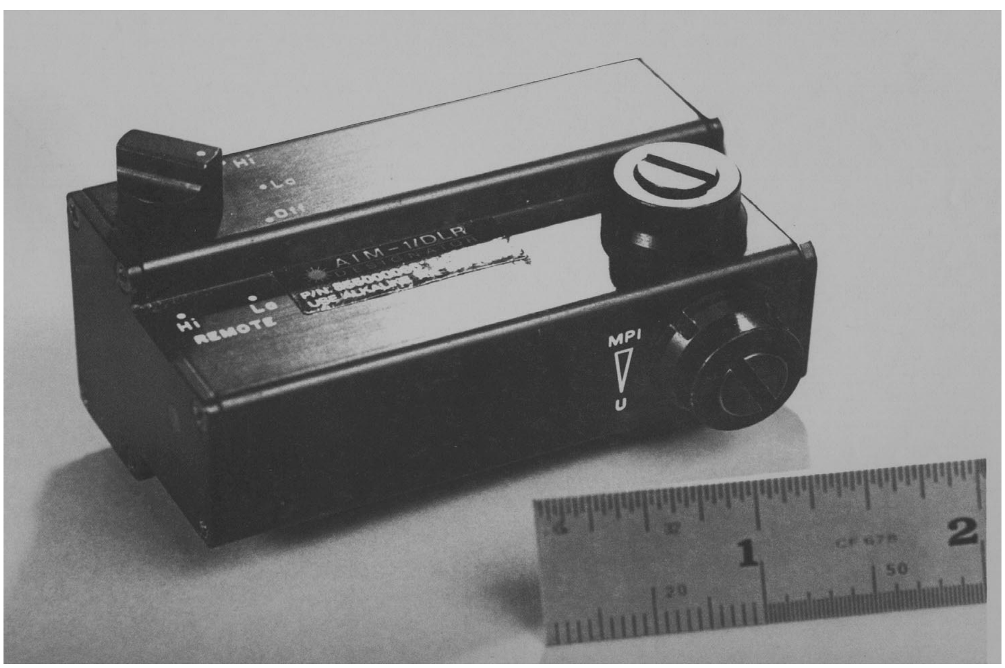

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Figure 2-13.—AIM-1DLR laser aiming device.

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Figure 2-14.—AN/PVS-X MLRF.

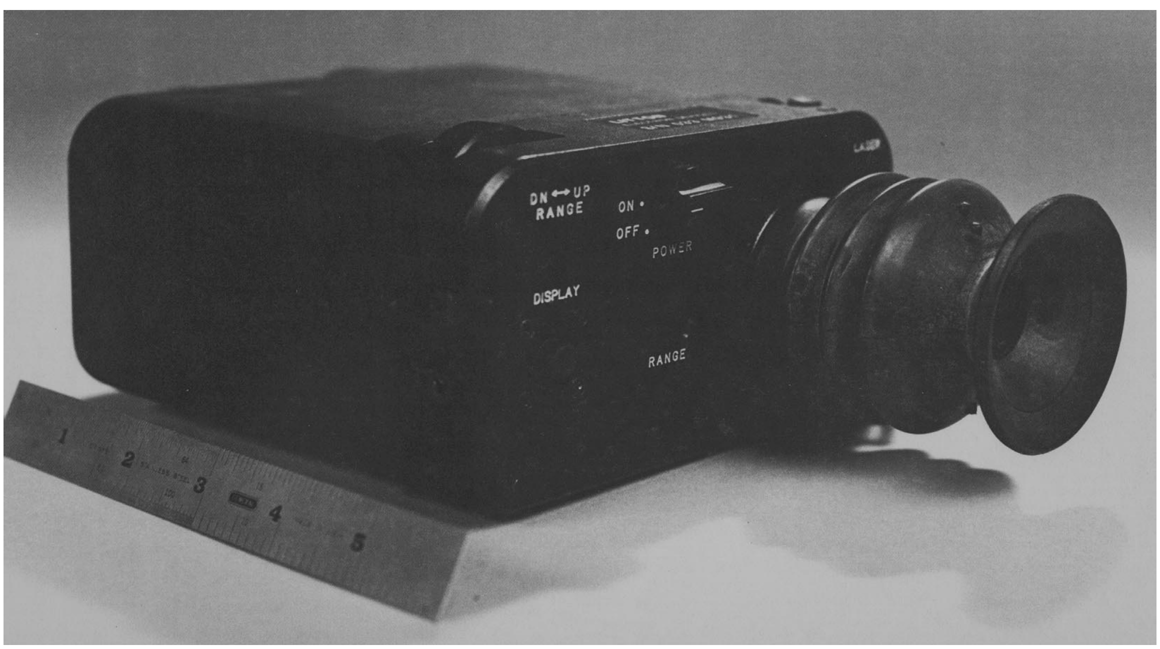

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Figure 2-15.—M931 RNS.

AN/KAS-1 CHEMICAL WARFARE DIRECTIONAL DETECTOR (CWDD)

The AN/KAS-1 CWDD illustrated in figure 2-16 is a passive device, two fields of view, forward-looking infrared system used by the Navy for standoff detection of nerve agents. The unit can be bracket-mounted on a ship's signal bridge or tripod mounted. It is used: (1) as a chemical warfare advance warning system and (2) for surveillance and navigation and search and rescue operations during hours of darkness, periods of limited light visibility, and during daylight operations.

The AN/KAS-1 weighs approximately 27 pounds and has a range of 3200 yards. It is powered by 115 volts ac, 60 hertz at 36 watts. Its field of view is 3.4 X 6.8-degrees wide and 1.1 X 2.2-degrees narrow.

MAINTENANCE

Most maintenance on laser equipment is preventive maintenance only (i.e., clean and inspect) and can be completed with little-to-no problems. Correc-tive maintenance is primarily limited to the depot level. Therefore, if you experience a major problem with laser equipment, you must send it to the Naval Surface Warfare Center, Crane, Indiana, for repair.

Throughout this chapter, we have introduced laser devices that are in use in the Navy today. This area of technology is continually expanding. As it does, your knowledge of this area should also grow.

This volume has introduced you to a small amount of the night vision equipment and laser devices that are used in today's Navy. Remember to follow all safety precautions when using these equipments. Your eyes cannot be replaced.

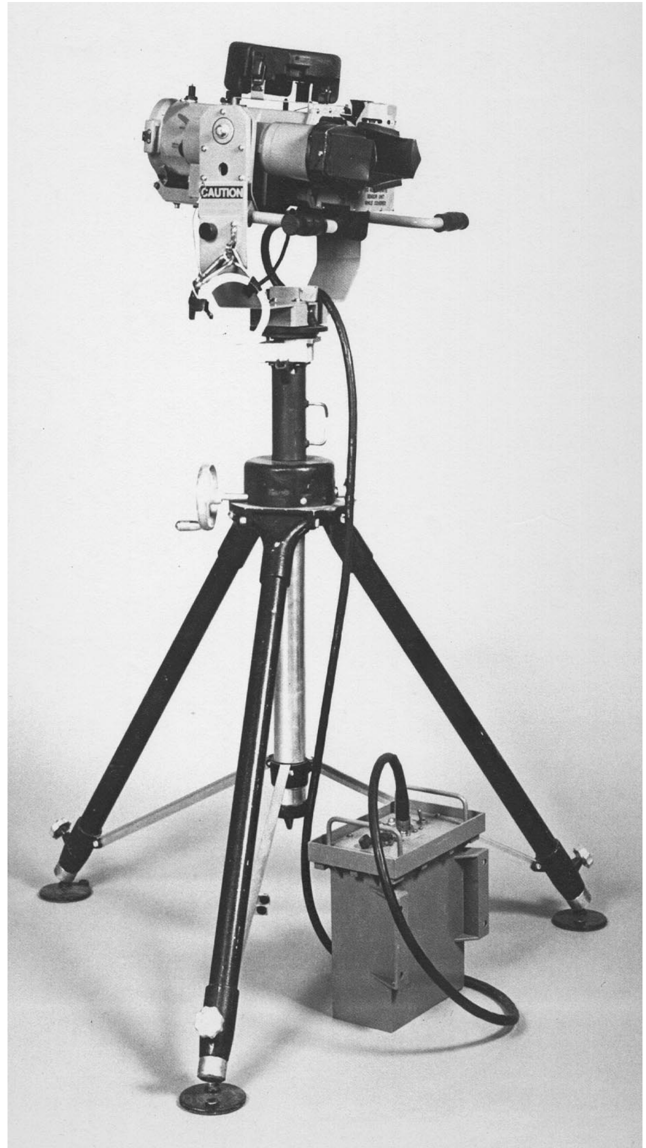

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Figure 2-16.—AN/KAS-1 CWDD tripod-mounted.